BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D. C. 20024

SUBJECT: On the Alternatives for the Data Relay Satellite System Program Case 900

DATE: March 14, 1969

FROM: R. K. Chen

ABSTRACT

The development of a Data Relay Satellite System (DRSS) to augment the present MSFN, STADAN, and NASCOM networks is a specific objective of two planning panels under the NASA Planning Steering Group (PSG). Four primary program alternatives are suggested in this memorandum for the DRSS. Three of the four alternatives are characterized by the singular emphasis in their respective approaches, namely: (1) an independent DRSS program, (2) an ATS oriented program, and (3) and Intelsat oriented program. The fourth alternative is the use of a DRSS which would be part of a multi-purpose integrated spacecraft, either manned or automated. The task of deciding on a workable set of alternatives is appropriate to the planning panels of the PSG.

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MEMORANDUM FOR FILE

I. Introduction

The concept of using a Data Relay Satellite System (DRSS) to augment the Manned Space Flight Network (MSFN) has been investigated for several years. More recently, the same concept has been extended so that a DRSS would serve automated spacecraft as well as manned spacecraft. The development of a DRSS program is a specific objective of two planning panels under the NASA Planning Steering Group (PSG); these are the planning panel on communications, and the planning panel on tracking and data acquisition. It can be visualized that a fully deployed DRSS would partially replace the present MSFN, STADAN, and NASCOM networks; moreover, it could be totally integrated into a new network.

This memorandum suggests several alternatives in the development of a DRSS program. The rationales for the development of these program alternatives are discussed in Section II, and the alternatives suggested are given in Section III. Section IV contains some additional comments.

II. Stages in DRSS Program Development

The DRSS program could be divided into four phases, they are:

1. feasibility,
2. development,
3. proto-operational and
4. operational

Feasibility Phase

From the technical viewpoint, the feasibility of having a DRSS should no longer be questioned. There are satellites in orbit today that are capable of performing the

data relay function; these are the ATS-1 & 3 using VHF frequencies and Intelsat III using C-band frequencies. However, the utility of these satellites for data relays has not been demonstrated, principally for the following reasons:

1. lack of user spacecraft (automated or manned) with compatible terminal equipment, and

2. policy limitations.

This brings out one unique aspect of the program development of a DRSS, that is, the requirement for a compatible user spacecraft to be in orbit concurrently. Further down the line, ATS-F & G will also have the capability and characteristics for a potential data relay satellite (DRS). Moreover, these satellites will have considerably higher capability than today's satellites. An experiment using ATS-F as a DRS has been proposed for a manned spacecraft (AAP backup workshop) and an automated spacecraft (Nimbus-E). Therefore, efforts in determining the feasibility for the DRSS program should be oriented towards the future, specifically, in the area of subsystem development that may be used for DRS's of the future generations.

Development Phase

By nature, DRSS is a service satellite system; its usefulness relies on the demand of its users. The capacity of the system, hence its usefulness, depends not only on the design of the DRS but also depends on the design of the user terminal. Therefore, in the development of a DRSS the two designs (or the design concepts) must evolve simultaneously so that both technical (in terms of bit rate) and operational requirements (coverage, access, multiple access etc.) are satisfied. It is not expected that the DRSS can be designed to satisfy all individual user spacecraft, the design will probably be compromised so that certain limitations on the system must be applied. These limitations will be in the following areas:

1. RF frequency and its respective bandwidth occupancy,

2. numbers of users to be served simultaneously,

3. user spacecraft orbit,

4. Antenna gain to system noise temperature ratio (G/T) of DRS receiver, and

5. Effective isotropic radiated power (EIRP) of DRS.

All of these limitations are influenced by the state of the technology, with the exception of the first which is also policy limited. The implication is that, during the programmatic development of a DRSS, the users must be willing to accept the limitations dictated by the available technology and balance that against the timeliness of having a DRSS. Furthermore, in the continuous development of the DRSS, the SRT requirements, the newly available technology, and the past operational experiences must be cohesively phased into the picture so that the later generation DRSS will be deployed and used without service interruptions.

Proto-operational Phase

The proto-operation concept, as the term implies, is the deployment of a prototype DRS for engineering check-out; and if successful, it would be utilized for experimental operation. Examples of this operational concept are Tiros prior to its operational version of TOS, and Syncom prior to its operational version of Intelsat I. During the proto-operational phase, the DRS is not only checked out with its compatible user spacecraft in the hardware sense, but the operational procedures and control interfaces will also be established. The latter experiences are especially valuable and necessary for the eventual establishment of fully operational mission and network control centers. Moreover, the availability of the orbiting proto-operational DRS would allow testing of various multiple access, modulation techniques and other experiments; many of these tests can be done by using ground stations to simulate the user spacecraft. Needless to say, the total experience gained from the proto-operational DRS would serve to modify and improve the design of an operational DRS.

The major point of the proto-operational concept for a DRS is that the prototype satellite can be a simplified version of an operational DRS but would contain all the necessary electrical and operational characteristics for checkout purposes. Therefore, it can be relatively inexpensive and be deployed at an early date.

Operational Phase

A fully deployed operational DRSS would be treated as a partial replacement of the present MSFN, STADAN, and NASCOM networks; moreover, it could result in a single integrated network. The DRSS should be capable of expanding

its capability with the timing and the growth of the user's demand in a well planned and organized manner. This may be done by the deployment of additional DRS of the current version for expediency, and, eventually, the deployment of an improved version which has higher capability. Hopefully, during this orderly growth process, many of the operational limitations will be removed through the improvement in technology (user terminal equipment and DRS); but more important, during this process the user's demand could be satisfied without any service interruptions.

III. Alternative DRSS Program

The alternative programs developed here should be viewed as being technically viable. Some of them or, for that matter, all of them might not be ultimately palatable when other factors are considered, some of these other factors are:

(1) policy,

(2) cost effectiveness,

(3) budget limitation, and

(4) timeliness.

Therefore, these alternatives are offered as a start for further considerations.

Four alternatives are defined, the first three are more project oriented and the last one suggests the possibility of making DRSS a part of a multiple purpose spacecraft, automated or manned.

Figure 1 is a flight schedule for existing, anticipated, and assumed DRS related satellites and user spacecraft. It is clearly seen that the evolvement of user-spacecraft is very weak. The earliest potential user is the AAP backup workshop. The status of this potential user is partial completion of a Phase B study (system definition) without any experiment approval from the Manned Spaceflight Office. Indeed, the mission may not even take place. Therefore, it is not unreasonable to assume that the earliest need for a DRSS would be beyond 1972.

Alternative 1 - Independent DRSS Oriented

Figure 2 is a program flow chart for an independent DRSS oriented alternative. As the description implies, the DRSS would be handled as an independent project but utilize the technology developed from the ATS project where appropriate. It is envisioned that the initial DRS may serve as a proto-operational system with limited capability, and will be followed by an operational version in one or two years. In the subsequent development of later generation satellites, the proto-operational phase can be relegated to the DRS which is being replaced.

Using this approach, a proto-operational satellite can probably be launched in 1973, and the operational DRS can be launched in the 1974-75 time frame.

Alternative 2 - ATS Oriented DRSS

Figure 3 is a program flow chart for a DRSS which is heavily oriented toward and, possibly, a part of the ATS project. As mentioned previously, the ATS - I and III which are in orbit, and the ATS - F and G which are being developed have the capability of serving as a DRS. Therefore, it is proposed that the mainline ATS's be used as a DRSS to the stage of being proto-operational. A simplified version, but a direct descent, of the ATS (stripping off all the non-related experimental systems) would be used as the operational DRSS. It is possible that some of the other experiments can also be carried for operational usage as long as they are compatible with DRSS operations.

Using this approach, ATS - F and G can serve as proto-operational DRS in 1972, and the derivatives of ATS - F and G can serve as the first generation operational DRSS probably in 1974.

Alternative 3 - Intelsat Oriented DRSS

Figure 4 is an organizational flow chart for a DRSS which is oriented towards utilization of Intelsat satellites. The concept here is that communication between an orbiting spacecraft and earth can be eventually accomplished in a manner similar to using a telephone from a moving train. A precedent has been established of using Intelsat satellites (Intelsat II) from a non-Intelsat terminal (Apollo ships, Vanguard, Redstone, and Mercury) on a dedicated private line

basis for spaceflight operations (Apollo). Therefore, one can extend this concept to an orbiting spacecraft by considering it as an orbiting Vanguard or Redstone. An attractive feature of this approach is that in 1972, when the earliest user-spacecraft may be readied, Intelsat IV would be in orbit. Therefore, between now and then, the only immediate task would be the development of a user terminal. Since Intelsat IV's capability is limited (less than ATS-F), it is proposed that it be considered for use as a proto-operational DRSS. Looking forward to an operational DRSS, it is suggested that the unique DRS requirements to be phased into Intelsat V which is expected to evolve as part of Intelsat's normal replacement cycle. The basic idea is that part of the Intelsat satellite could be utilized for spaceflight operations; initially on a dedicated private line basis and eventually on a demand access basis. With this approach, the mainline ATS project would serve as the basis for technology development as it is at the present time.

Alternative 4 - Multi-purpose Integrated Spacecraft

A DRSS could be part of a multi-purpose integrated spacecraft, automated or manned. A large manned space station in synchronous orbit in the 80's is a possibility. As usual, a multi-purpose spacecraft generates many interface problems; therefore, this particular approach would need to be studied carefully to determine its feasibility.

IV. Additional Comments

One notable item in Figures 2 to 4 is that the DRS and the user spacecraft must be considered simultaneously in the development of any DRSS program. This point has been mentioned before, and it deserves to be emphasized.

Alternatives 1 to 3 suggested in Section III may be classified as the primary program alternatives. They are characterized by well defined and singular emphasis in their respective approaches. Additional alternatives can be made by intermixing various stages from the primary alternatives; and one of them may prove to be the optimal combination. The task of deciding on a workable set of alternatives belongs to the planning panels of PSG.

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R. K. Chen

Attachments:
Figures 1 through 4

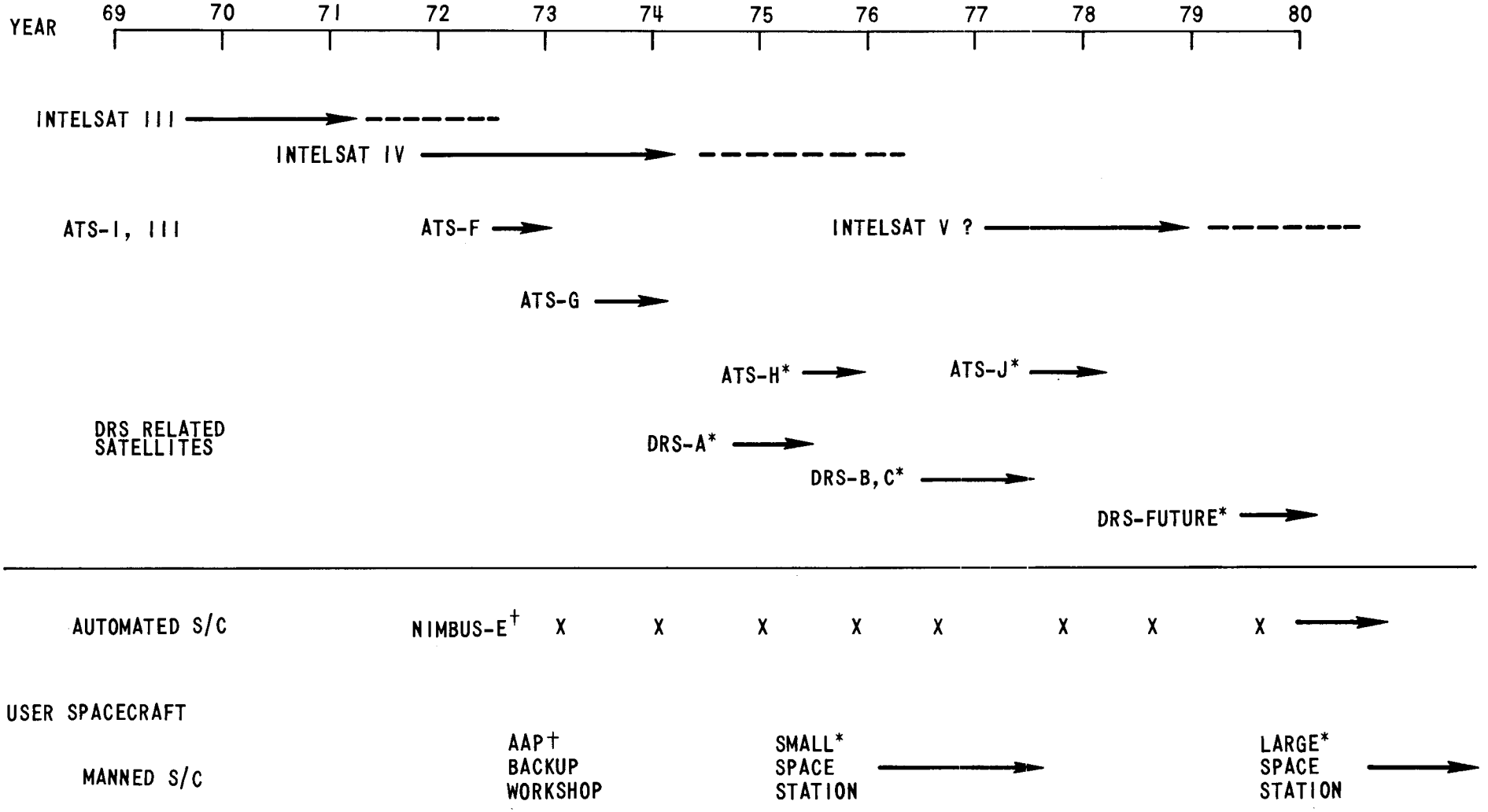

FIGURE 1 - FLIGHT SCHEDULE FOR EXISTING ANTICIPATED AND ASSUMED DRS RELATED SATELLITES & USER SPACECRAFT

X - UNIDENTIFIED USER S/C ASSUMED TO EXIST NUMBERS UNKNOWN
* - NOT APPROVED & ASSUMED
† - EXPERIMENT PROPOSED TO USE ATS-F AS DRS

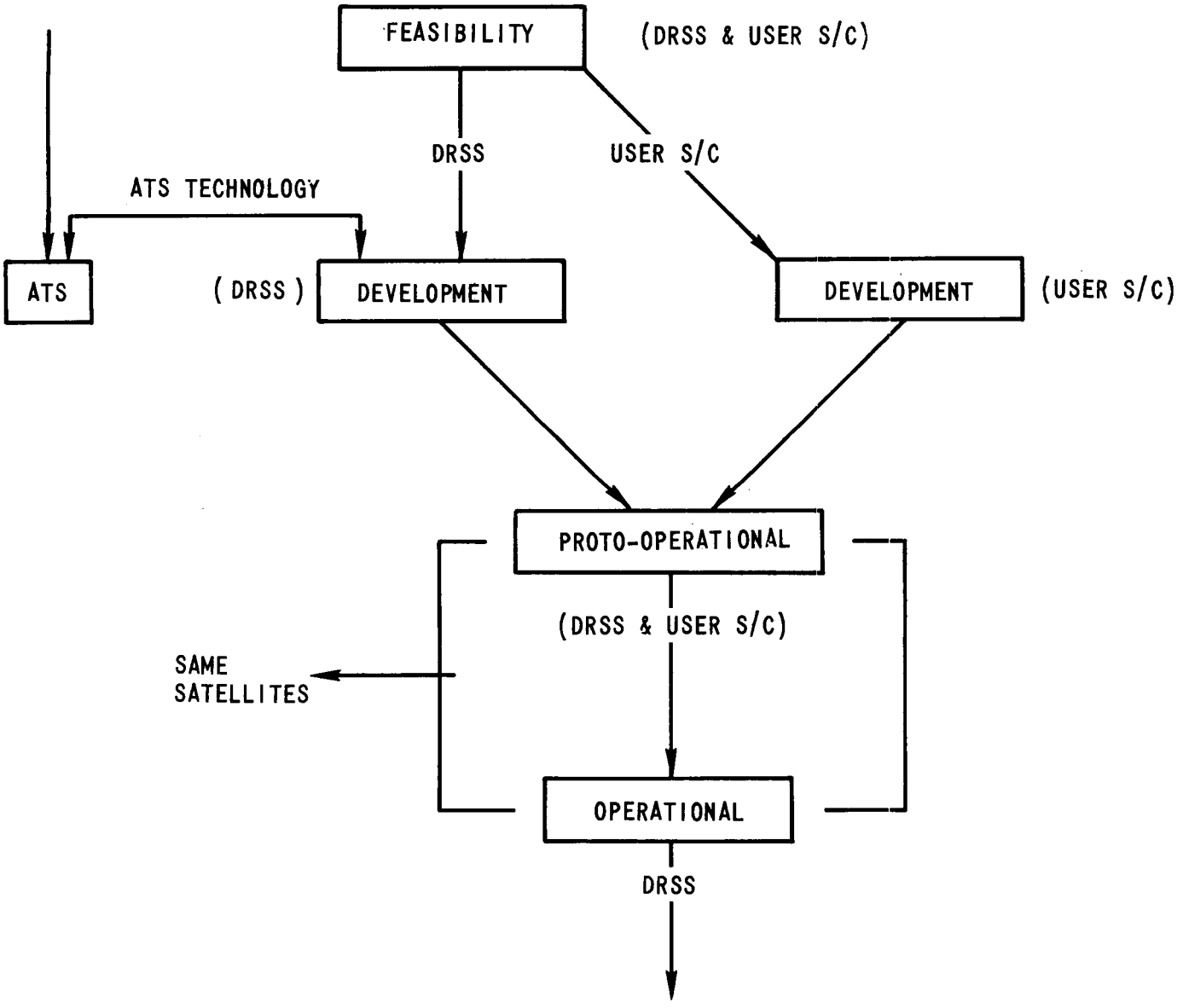

FIGURE 2 - ALTERNATIVE I INDEPENDENT DRSS ORIENTED

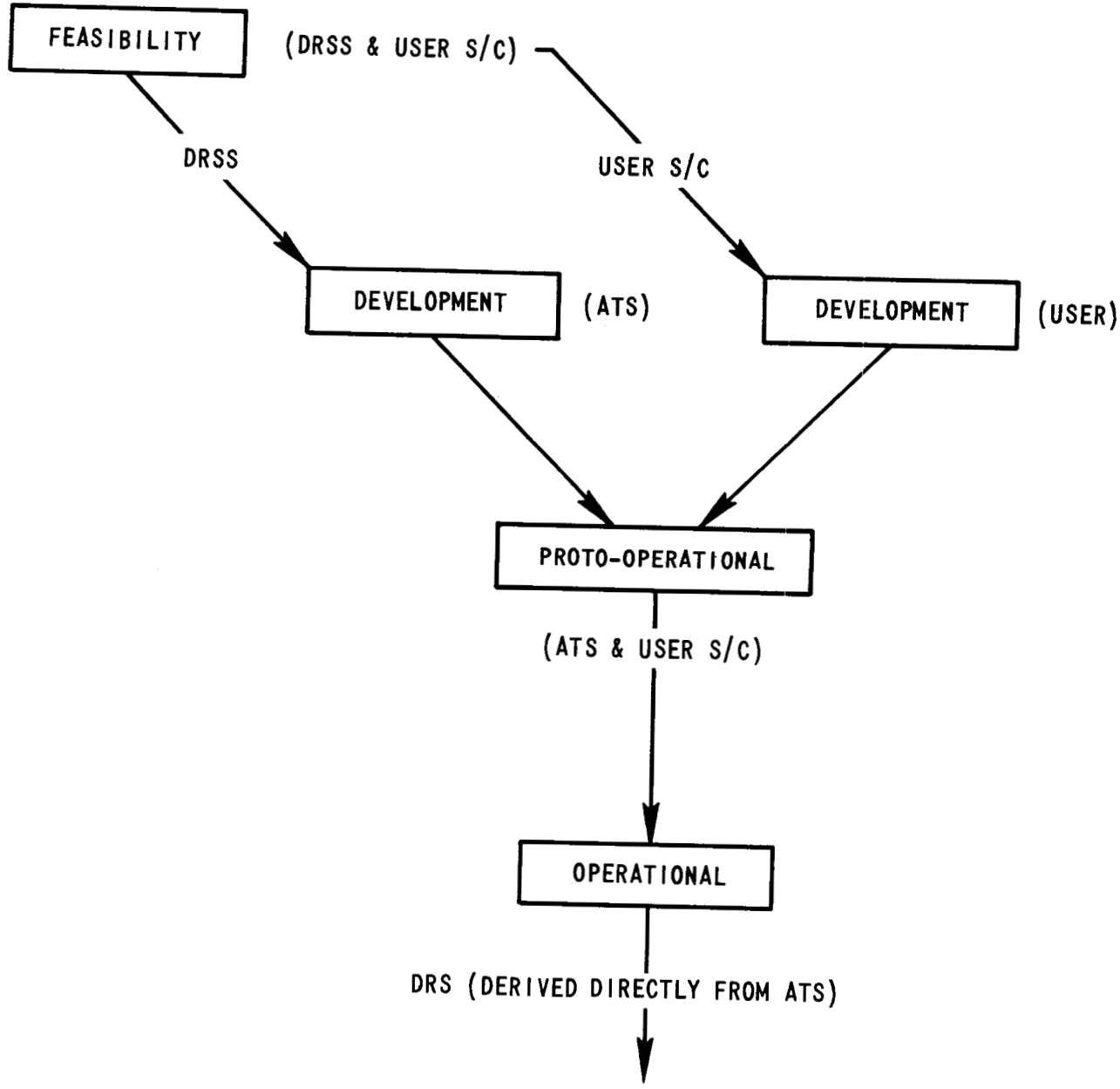

FIGURE 3 - ALTERNATIVE 2 ATS ORIENTED DRSS

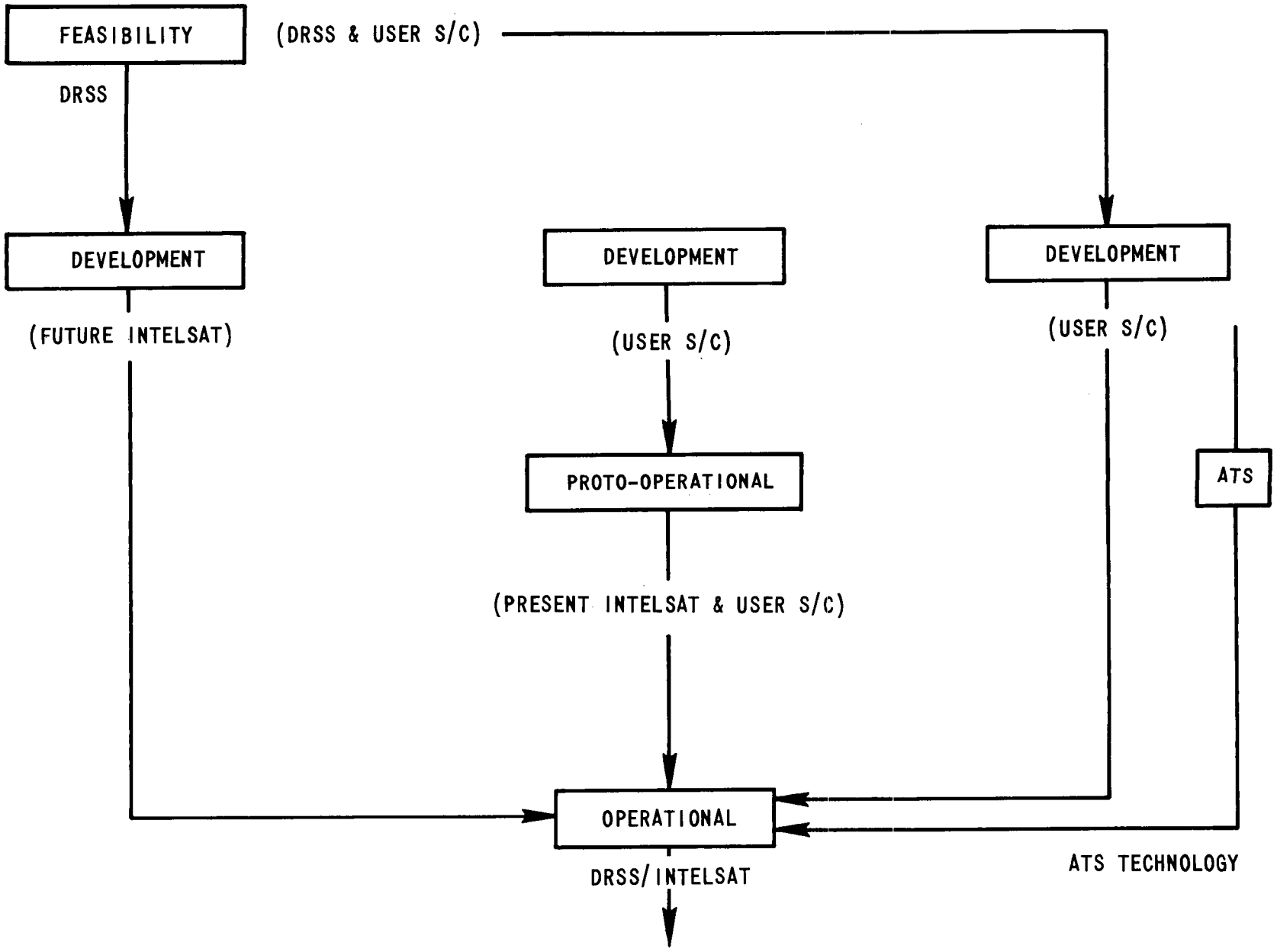

FIGURE 4 - ALTERNATIVE 3 INTELSAT ORIENTED DRSS

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